

Not to be cited without permission of author

Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC
Research Document 80/61

Updated Assessment of the Eastern Scotian Shelf
(4VW) Haddock Stock with Projections to 1981

by

D.E. Waldron
Marine Fish Division
Department of Fisheries & Oceans
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, N.S.
Canada
B2Y 4A2

Abstract

Research vessel surveys of the eastern Scotian Shelf indicate that the resident haddock stock has been increasing in recent years. This increase in biomass estimates has been complimented with only slight increases in landings. The stock assessment for this haddock stock indicates that the 1979 fishing mortality is less than that calculated in previous years. Projection to 1981 indicates increases from 2,000 t TAC in 1979 to a 23,000 t TAC in 1981.

Résumé

Les relevées des navires de recherche sur le plateau néo-écossais oriental indiquent que l'abondance du stock d'aiglefin a augmenté au cours des dernières années. Les débarquements ont toutefois augmenté dans une proportion moindre que les estimations de biomasse. L'évaluation de ce stock suggère que la mortalité par pêche en 1979 est inférieure à celle calculée pour les années antérieures. Les projections indiquent que le TPA va passer de 2,000 t en 1979 à 23,000 t en 1981.

INTRODUCTION

The Scotian Shelf haddock stocks are divided into two groups: the ICNAF Divison 4VW and 4X stocks (McCracken 1963). Between 1960 and 1975, the eastern Scotian Shelf haddock stock (4VW), was exploited primarily by the Canadian, Spanish, and Soviet fleets. Prior to 1965, this stock was fished at levels from 13,000 tons to 34,000 tons averaging 27,000 tons. In 1965 the total fleet reported a large haddock catch of 55,000 tons which was twice that of the pre 1965 average of 27,000 tons (Fig. 1). Canadian catches accounted for 8,700 t of this total, while the USSR caught 43,000 t. After this, the fishery decreased to yearly levels from one-half to one-eighth of those prior to 1965. This decrease continued until 1977 when the catches began an upswing under stringently low TACs.

The Canadian domestic fishery for 4VW haddock was exploited by large trawlers (TC 4 and 5), long-lines, traps, and hand-lines. Those fisheries conducted by the USA, USSR, and Spain, used trawlers ranging in size from TC 4 to 7. Spain used primarily pair trawlers while the USA and USSR employed both side and stern trawlers.

Peak catches by Canada occurred in 4W during late winter and early spring (Figure 2). Both the USSR and Spanish fleets fished during the summer and early fall in 4W and 4VW respectively.

Most foreign catches of haddock were a by-catch to some other species. The USSR haddock catch was almost exclusively a by-catch of the small mesh silver hake fishery with the possible exception of the 1964 to 1966 fisheries. Spanish vessels caught haddock as a by-catch in their cod fishery. The Spanish cod fishery persisted until 1975, while the USSR continues to fish for silver hake today, although within a rather restricted area.

For the years 1963 - 1966, the USSR concentrated its fishery on Middle Ground and the southern tips of Banquereau and Sable Island Banks (Clay 1979). Both Scott (1979) and Hare (1977) indicate that the latter area is one which has a high concentration of haddock.

POSSIBLE IMPACT OF SMALL MESH FISHERIES ON 4VW HADDOCK

Halliday (1971) suggests that the selectivity of the 40 mm nets used in the Soviet silver hake fishery would be similar to that used on Canadian research vessels (32 mm). Data reported to ICNAF suggest that 67% of the 1965 USSR haddock catch was obtained in a directed silver hake fishery. Also, the catch of haddock for the directed silver hake fishery was reported to be 41% of the silver hake catch by weight. Such data suggests that these two fisheries were being conducted simultaneously.

The USSR fishing patterns reported by Clay (1979) indicate that the USSR fished the same areas from 1963 - 1965, yet the by-catch in 1963 and 1964 was well below the 1965 level (3 - 7% compared to 41%). Therefore, it is highly unlikely that the USSR would have equipped its vessels with 114 mm nets in order to direct a fishery toward haddock for only one year. The most plausible scenario would be that the USSR small meshed fishery was capitalizing on the large 1962 and 1963 year-classes of haddock (Table 1).

Further adjustment to reported catches for the USSR were calculated from data collected during the 1977 and 1979 Observer Programs. Comparison of reported by-catch of haddock in the 1977 USSR silver hake fishery (0.1%) to that actually observed (1.0%) demonstrates that the USSR could have under reported its catch by 111 tons (Waldron 1978). Similar results were observed in 1978 and 1979 where it was estimated that the USSR may have under reported its haddock catch by at least 246 and 405 tons (Table 2) (Waldron 1979). These quantities, although small in relation to the total 4VW haddock catch, are nonetheless important since they represent predominantly 1 and 2 year-old haddock (Table 3).

These adjustments are likely to be underestimates of the actual events since the current silver hake fishery has been restricted to an area south of Sable Island. Experiments to evaluate the placement of this line were conducted in both 1977 and 1978. Both the USSR and Cuba suggested the studies would benefit directly by not only removing restriction on where the vessels could fish but also eliminating the 1% by-catch regulation for cod and haddock. The results may have been biased with fleet commanders attempting to minimize the amount of by-catch, yet they do demonstrate that by-catches of haddock in a directed silver hake fishery on the Shelf, ranging from between 1.1 and 3.7%, were higher than those observed in areas near the slopes which ranged from .5 to 2% (Waldron 1979). These observations would increase again the total haddock catch in small-meshed fisheries from those estimated.

RESEARCH VESSEL SURVEYS

Random stratified surveys of the Scotian Shelf have been conducted since 1970 during July and August. The estimated 4VW haddock biomass has varied from a low of 9,000 tons to a high of 69,500 tons. Generally there has been an increasing trend since 1974, with 1978 and 1979 estimates being 69,500 tons and 69,400 tons respectively (Fig. 3). The decrease in numbers reported for 1979 is primarily due to the conspicuous absence of the 1978 year-class (Table 4).

The 1979 survey also suggests that the 1979 year-class is the largest in the history of these surveys. Although there are subsequent cruises in 1979, the data are not yet available to corroborate these observations.

EFFORT STANDARDIZATION

The most consistent effort series was that of Maritime-based TC 4 vessels. Directed CPUE and total catch of OTB 1 and 2 from February to June were obtained from ICNAF statistics. Catch per unit of effort for tonnage classes 3 to 5 were standardized to 1966 (Table 5). These indices were weighted to the total OTB catches for that year. The final effort index was obtained by dividing the total catch of all fisheries by the weighted CPUE index.

In some years the Maritimes-based vessels caught less than 30% of the reported catch, both Spain and the USSR reported most catches of haddock as by-catches of either a directed cod or silver hake fishery. In recent years, the offshore catch of haddock has decreased by all gears. The percentage removed by OTB and long-lines has remained fairly consistent, except during the period 1974-1977 when long-lines increased their take. The effort series is affected both by the low percentage of total removals and the fact that the CPUE index is based on only part of the population supporting the fishery i.e. older age groups (see below). Thus it is not likely that this effort series will reflect total effective effort in the fishery.

REMOVALS AT AGE

Historically, there have been three major fishing fleets operating in the 4VW haddock fishery. The Spanish and Canadian fisheries were required by regulations to utilize 114 mm gear until 1974 and 130 mm through to present, while it is speculated that the USSR utilized 40 mm gear (Halliday, 1971). Removals at age for all countries except the USSR were calculated from Canadian commercial age length keys (Table 6).

The high catches of haddock by the USSR in 1965 were unsampled. The only USSR samples reported to ICNAF were from 1966 and consisted of three age, and 14 length frequency, samples. USSR removals for 1960, 1965, 1967, 1969, and 1970-76 were calculated from Canadian research

vessel cruises which used mesh sizes of approximately 35 mm. The years 1961-64 were extrapolated from the 1960 Canadian research vessel cruise, while 1968 used the average of the 1967 and 1969 research cruises. Removals at age for 1977 and 1978 were obtained from Canadian sampling onboard USSR vessels.

Comparison of 1977 Canadian research and observed estimates of Soviet removals at age showed similar results, estimates of both indicating full recruitment at age 2 (Table 7). Age 0 fish caught by the Canadian research vessel were not observed in USSR vessel catches. This should not necessarily be interpreted as implying that the USSR did not catch 0 group fish but, rather, it could represent sampling variation. In order to avoid bias in population estimates, age 0 fish are not included in the cohort analysis. The removals at age matrix used in the cohort analysis (Table 10) is the summation of USSR removals (Table 3), Canadian (Table 6) and for 1979 other countries estimated removals-at-age (Table 8) based on observed and reported data (Table 9) adjusted to USSR removals-at-age.

STOCK ASSESSMENT (Option 1, reported catch).

Partial recruitment - An initial partial recruitment vector was derived from a relationship between commercial fishery removals-at-age and research vessel estimates of population numbers-at-age in 1979. Research vessel numbers at ages 1, 2 and 3 for 1979 were adjusted to compensate for partial recruitment to the survey gear relative to age 4 (Tables 11a to 11b). The resultant numbers-at-age were divided into the commercial numbers-at-age and plotted against age in order to obtain the initial partial recruitment (Table 12). Full recruitment occurred at age 6 and partial recruitments for earlier ages were read from the curve. These were used during the initial runs of the cohorts. A partial recruitment of 0.040 .050 .178 .550 .673 1.0 1.0 1.0 1.0 1.0 for ages 1-11 was finally utilized as this gives a high correlation ($r = 0.97$) between numbers at age 1 from the cohort and numbers at age 1+2 in research vessel surveys.

Fishing Mortalities - Starting F 's were calculated for each year from average Z values after full recruitment. The cohort began with a terminal F of 0.2 derived from an earlier assessment and M of 0.2. Effort calculated from the weighting of commercial CPUE did not give any statistically significant relationships with F . With the above partial recruitment and terminal F 's, cohort runs were made to find the final F which gave the greatest GM correlation between estimates of age 3+ numbers from the cohort and research vessel surveys (Fig. 4). The best ($r = 0.96$) was obtained with an F of 0.1 (Table 13).

Recruitment - The geometric relationship between age 1, as calculated from the cohort analysis, and age 1 + 2 from research surveys gave an $r = 0.97$ (Fig. 5). The 1962-64 year-classes were the largest in the time period studied (Table 13). However, the assumptions involved in determining removals at age will have resulted in some smoothing over adjacent year-classes. From analogy with haddock stocks to the southwest of 4VW, it is likely that it was the 1963 year-class which was extraordinarily large. The 1962 year-class

was probably also above average strength, but neither it nor the 1964 year-class are likely to have been quite as strong in relation to the 1963 year-class as shown here. The 1965 to 1973 year-classes were extremely poor. However, the 1974-77 year-classes, which are responsible for the recent increase in population abundance are comparable in size to those of 1959-61.

For projection purposes the 1979 year-class size at age 1 was assumed to be equal in size to the geometric mean of age 1 numbers over the years 1970-78 i.e. 14.0 million fish.

YIELD PER RECRUIT

Using mean weights at length obtained from research vessel cruises, with length at age in commercial catch sampling data, and using partial recruitments as derived for 1979, a Thompson-Bell yield analysis was run. This gave a maximum yield per recruit at age 1 of 0.630 kg at a fishing mortality of 0.60. $F_{0.1}$ was 0.31 and gave a yield per recruit of 0.585 kg. (Table 14).

PROJECTION

The projected catch in 1980 at $F_{0.1}$ is 18,500 tons.

Year	Population Age 1+		Catch	
	Numbers (x10 ⁻⁶)	Biomass (tons)	Numbers (x10 ⁻⁶)	Weight (tons)
1979	121.3	114,000	3.0	4,000
1980	110.5	126,000	12.3	18,500
1981	93.4	123,000	12.7	22,400

Stock Assessment - Option 2 (Increased catch)

Terminal F for option 1 resulted in a vector of F's lower than those calculated for previous years. Although the standard correlations described in Option 1 were maximized the resultant 1979 fishing mortalities were well below those calculated for previous years (table 13). The reason for this apparent dichotomy of high correlations and low terminal F were unexplainable with the data available.

It may be postulated that the low terminal F was the result of correlating the cohort to research vessel surveys which could conceivably be biased upward in most recent years. The low catch in 1979, compared to 1977 and 1978, did not correspond to the increasing biomass estimates from research vessel surveys. However, indications, from both Federal Government fisheries management personnel and contracted observer reports, are that more haddock were caught by Canadian vessels in 4VW than what was reported. As the raising of the reported Canadian catch would increase the terminal F calculated in Option 1, this option is investigated.

Ratios of numbers-at-age from cohort analysis and research vessel surveys, in Option 1, suggested that cohort analysis progressively underestimates older aged haddock.

Period/Age	<u>Ratio Cohort/Research numbers-at-age</u>										
	1	2	3	4	5	6	7	8	9	10	11
1970-73	1.7	.9	1.0	1.2	1.7	1.2	1.7	1.1	2.7	-	-
1976-79	2.1	1.1	1.0	.6	1.0	.6	.5	.7	-	.3	.3

This underestimating could be caused by a terminal F which is too high or removals in the last year being too low. The latter explanation is favoured for, as has already been pointed out, the Option 1 terminal F is substantially below those calculated for 1977 and 1978.

Removals-at-age

Removals-at-age for 1960-1978 remained the same as those used in Option 1. Removals-at-age for ages 3 and greater, in 1979, were adjusted upwards to reflect a total catch of 10,000 t while ages 1 and 2 removals remained unaltered as follows:

Age	<u>Removals-at-age</u>										
	1	2	3	4	5	6	7	8	9	10	11
1979 Option 1	1	202	570	1324	651	124	98	7	4	1	1
1979 Option 2	1	202	1425	3310	1628	310	245	18	10	3	3

Partial recruitment

The initial partial recruitment vector calculated in Option 1 was used for Option 2. Fishing mortalities for 1979 were iterated over the years 1975-1978. The highest correlation ($r = 0.98$) between cohort 1 and research survey 1 + 2 (same yearclass) numbers-at-age resulted in the following partial recruitment for ages 1 - 11: 0.005, 0.010, 0.080, 0.290, 0.418, 0.675, 1.000, 0.808, 0.640, 0.510, 1.000. Full recruitment occurs at age 7 as opposed to age 6 in Option 1.

Terminal Fishing Mortality

Several cohort runs were made using the above partial recruitment and various F's ($M = 0.2$). The best AM correlation ($r = 0.95$) between cohort analysis 3+ numbers and research vessel surveys 3+ numbers were obtained with an F of 0.4 (Figure 6, table 17). However, this correlation analysis appears to be insensitive for a range of F's from 0.1 to 0.6. Comparison of the above cohort to research values for terminal F's equal 0.4 and 0.6 suggest that a terminal F of 0.6 results in a closer agreement than does the similar values for a terminal of 0.4. However, the terminal F of 0.4 is favoured because of the overall correlation since 1970.

Recruitment

The geometric relationship between cohort age 1 and research vessel surveys age 1 + 2, with a terminal F of 0.4, gave an $r = 0.98$ (figure 7). For projection the 1979 year-class size at age 1 was assumed to be equal to the geometric mean of age 1 numbers over the years 1970 - 78 i.e. 15.0 million fish.

Cohort/Research Survey Ratios

Ratios of numbers-at-age from cohort analysis and research vessel surveys were calculated for Option 2. Although there are high correlations between commercial and research vessel data for recruitment and population numbers-at-age the relationship of these ratios for the periods 1970-73 and 1976-79 have not improved in Option 2. The cohort is still overestimating the younger ages. There is no definite explanation for the cohorts response except the Partial Recruitment used could be too low for ages 1 to 4.

	<u>Ratio Cohort/Research Vessel numbers-at-age</u>										
Period/Age	1	2	3	4	5	6	7	8	9	10	11
1970-73	1.3	.8	1.0	1.1	1.5	1.2	1.4	1.1	2.4	.9	.7
1976-79	4.2	1.5	.7	.4	.4	.5	.3	.4	2.5	.2	.3

Continued analysis of this option is not warranted and until the results of new research vessel surveys become available the results of Option 1 are favoured.

Discussion

Neither of the calculations of stock status given are particularly satisfactory. Option 1 produces an estimate of 1979 terminal F which is unreasonably low. Option 2 corrects this but requires assumption of the 1979 catch at a level substantially higher than that reported. It also produces estimates of recent yearclass sizes which rival the very large yearclasses of 1962-63 in size. While this is not impossible, there are no supportive data.

All these analyses depend heavily on the reliability of research vessel data and weight has been put on the assumption of catchability being independent of stock size. Irrespective of this, however, high survey estimates occur only in the last three years of the data series and any set of input parameters to cohort analysis which result in higher stock sizes in more recent years will produce high correlations between survey and cohort population estimates.

Under the circumstances, the calculations should be taken only as guidelines to management decisions. In the 1950's and early 1960's average catches were about 27,000 t under heavy fishing pressure. The present stock recovery is supported by 4 yearclasses, those of 1974-77, which appear to be at least as strong as the average in the 1950's. However, it is already clear from research vessel surveys that the 1978 yearclass is poor, and possibly extremely poor. Although the 1979 yearclass, from first indications, is good, this requires confirmation from future surveys. It would not be overcautious at this juncture to take the lower estimate of potential yield in 1981 i.e. the 22,000 t given by Option 1, thus allowing a steady expansion of the fishery while data for a refined assessment accumulates.

REFERENCES

- Clay, D. 1979. A preliminary review of silver hake (Merclussius bilinearis) stock distribution and differentiation on the Scotian Shelf. ICNAF Res. Doc. No. 79/15. Serial Number 5341.
- Halliday, R.G. 1971. Recent Events in the Haddock Fishery on the Eastern Scotian Shelf. ICNAF Research Bull. No. 8, p. 49-58.
- Hare, G.M. 1977. Atlas of the Major Atlantic Coast Fish and Invertebrate Resource Adjacent to the Canada-United States Boundary Areas. DFO Tech. Rept. 681.
- McCracken, F.D. 1963. Migrations of haddock between the Gulf of St. Lawrence and offshore Nova Scotian Banks. J. Fish. Res. Bd. Canada. 20: 855-857.
- Scott, J.S. 1976. Summer distribution of groundfish on the Scotian Shelf 1970-74. Env. Canada Tech. Rept. 635.
- Waldron, D.E. 1978. Catch compositions during the 1977 Scotian Shelf international ifishery with emphasis on the silver hake and squid (Illex) fisheries. ICNAF Res. Doc. 78/9. Serial Number 5161.
1979. Preliminary results of a joint International Observer Program to evaluate the silver hake small mesh gear line in ICNAF Division 4VWX. ICNAF Res. Doc. No. 79/17. Serial Number. 5343.

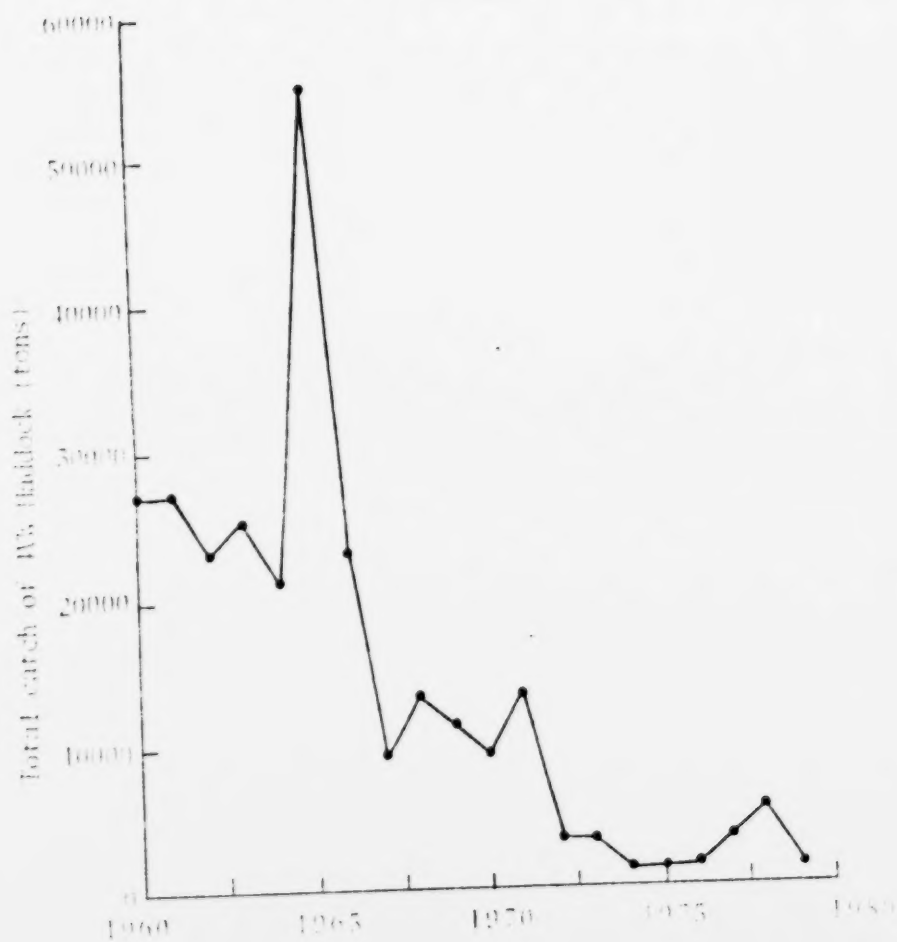


Figure 1. Plot of nominal catches of NW Haddock (tons).
Nominal catches for 1978 and 1979 are preliminary.

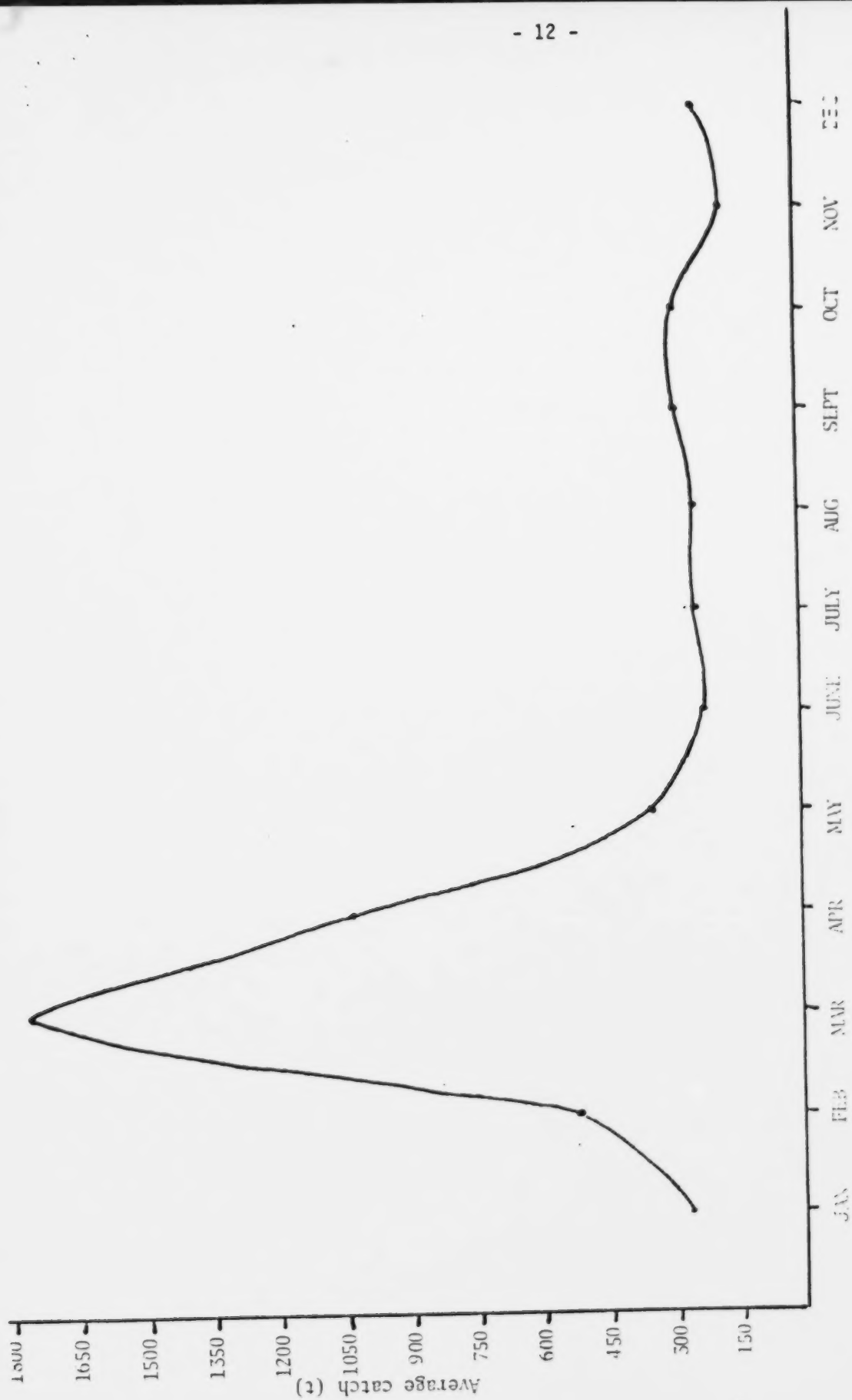


Fig.2 Average Monthly Catch of 4W Haddock (1969-78) by Canada.

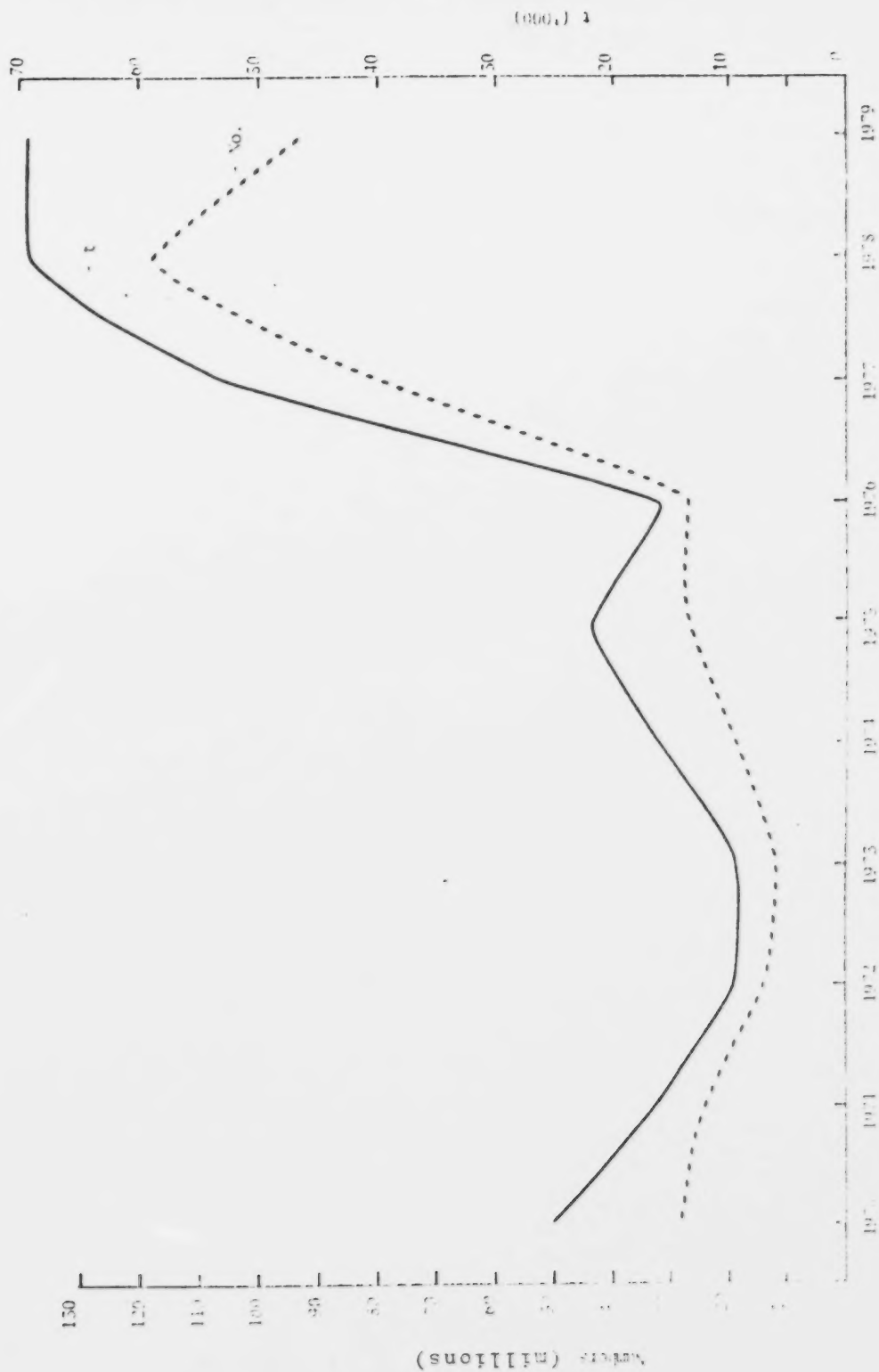


Figure 3. Research vessel estimate numbers and biomass (t) for the Haddock.

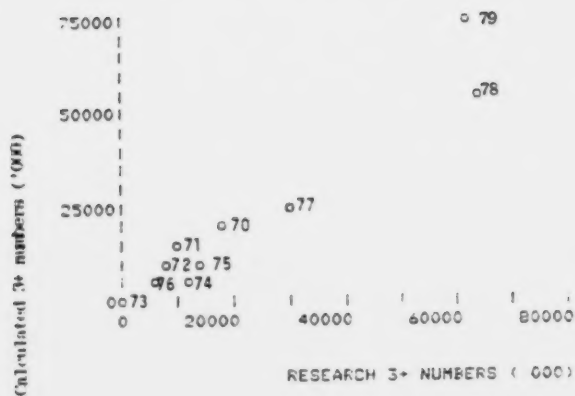


FIG. 4: CALCULATED 3+ NUMBERS ('000) AGAINST RESEARCH 3+ NUMBERS ('000) FOR THE 4VW HADDOCK STOCK. ($R = 0.96$)

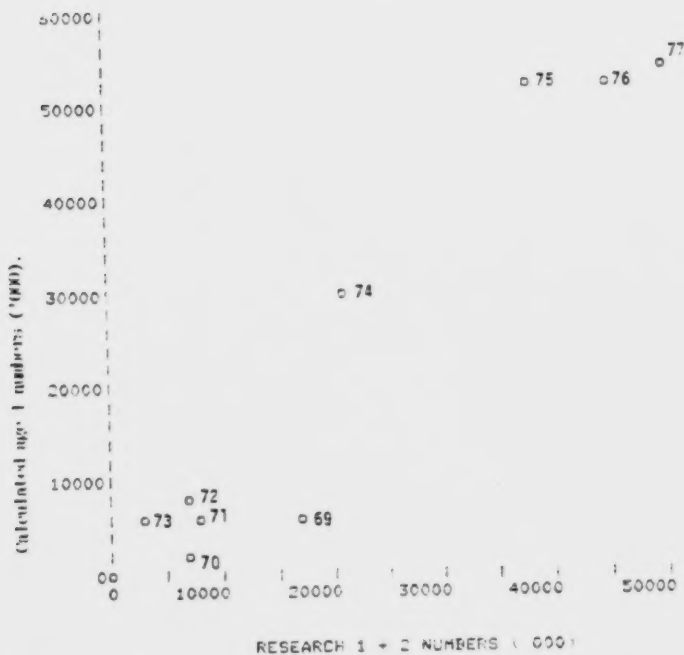


FIG. 5: CALCULATED AGE 1 NUMBERS ('000) AGAINST RESEARCH 1 + 2 NUMBERS ('000) FOR THE 4VW HADDOCK STOCK. ($R = 0.97$)



FIG. 6 : CALCULATED 3+ NUMBERS (000) AGAINST RESEARCH 3+ NUMBERS (000) FOR THE 34W HADDOCK STOCK, $r^2 = 0.95$



FIG. 7 : CALCULATED AGE 1 NUMBERS (000) AGAINST RESEARCH 1 + 2 NUMBERS (000) FOR THE 34W HADDOCK STOCK, $r^2 = 0.98$

TABLE 1 USNR DIRECTED S. HAKE FISHERY (44W) AND ASSOCIATED BYCATCHES (wt)

YEAR MONTH	1960			1961			1962			1963			1964			1965		
	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod
January										7081	9	663	160	10	103			
February										4101		4	100	7	255			
March										5810		1630	1207	177	706	18		
April							837	102	256	6763		1182	3	-	3			
May										38639	294	1256	29309	59	479	15577	148	507
June							1		1	23746	434	1292	678	10	253	511	74	80
July										2			13235	40	1317	14227	10797	593
August										13043	246	619	19531	300	3009	2040	2550	1023
September										12764	493	891						
October										1750	1655	1021	1			27		
November							4595	306	-	2403	602	853	67		3			
December							4678	232	-	2764	-	165	23			650	165	
Total Rpt. Dir. (Other)							5273	640	257	119335	3733	9531	64094	400	6768	33658	13342	2107
Total Reported				151	113		8025	3567	2383	118368	3901	9505	62905	400	7133	43644	42876	7566
Ratio							1.000	0.073	0.029	1.000	.032	.082	1.000	0.044	0.111	1.000	0.412	0.052

Clay, 1979

YEAR MONTH	1966			1967			1968			1969			1970			1971		
	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod	S. Hake	Haddock	Cod
January										400	20	33				3		
February										800	5	43	41			3246	25	5
March										1363	75	44	4326	56	155	27217		
April										9079	7	108	16546		615	19364	60	24
May				58	12		608	67	222	5935	5	55	17430	58	458	6746	68	42
June				1745	13	917							17473	100	160	9100	64	100
July				20						5215	51	339	34601	100	673	27118	18	40
August				10						12215	15	221	43165	50	58	21101	8	25
September										6982	45	1054	18707	107	175	8174	21	17
October							972		353	1631	-	431	6125	40	142	1757	5	5
November										1747	5	61	4115		43	581	2	8
December													1010		100			
Total Rpt. Dir.				1034	25	917	1573	67	611	44720	235	2619	164313	600	2513	127413	277	270
USNR Total Reported	3070	10501	6016	1034	554	1077	3305	254	4065	44760	235	2703	164313	600	2521	22445	475	450
Ratio				1.00	.014	.500	1.000	.042	0.302	1.000	.005	.059	1.000	.004	.005	1.000	.002	.006

TABLE 1. USSR DIRECTED SILVER HAKE FISHERY (1972) AND ASSOCIATED BYCATCHES (mt)

YEAR	1972			1973			1974			1975			1976			1977		
	S.Hake	Haddock	Cod	S.Hake	Haddock	Cod	S.Hake	Haddock	Cod	S.Hake	Haddock	Cod	S.Hake	Haddock	Cod	S.Hake	Haddock	Cod
January							1029	-	-	2381	-	108	982	11	75			
February				104	-	-				83	-	-	1146	-	68			
March	2166	20	217	11264	37	42	6763	-	40	2565	1	63	14644	1	177	37		
April	11115	-	39	67254	-	52	8762	3	249	12501	4	215	9579	-	137	4040	6	10
May	19075	-	471	71540	20	250	11107	27	1128	12100	9	517	4102	-	360	3721	2	10
June	16716	-	716	41103	17	1079	12017	15	470	5773	3	445				1820	2	
July	24043	35	971	38769	-	464	10114	6	311	23769	27	166	12719	-	62	8723		1
August	14610	38	339	13116	2	321	9883	29	347	18210	8	146	6028	5	-	14		
September	11481	1	136	8374	-	126	2072	-	-	17621	-	113	5058	-	19	675		
October	3213	-	166	5394	-	171	3628	1	47				6533	-	4	112		
November				1000	-	4	4639	-	140				3100	-	12	101	1	
December				7975	-	15	9607	15	97				4073	-	30			
Total	107769	102	2176	276293	76	2664	87101	91	2629	96793	50	1603	72064	10	972	20115	10	21
1972 Total Reported	102157	106	416	278511	75	2918	87437	130	3099	96803	50	1642	74823	21	1018	27261	14	9
Ratio	1.000	1.071	1.039	1.000	1.000	1.070	1.000	1.000	0.95	1.000	0.97	1.001	1.000	1.000	1.014	1.000	1.000	0.950

Table 2. Adjusted Haddock catches (t) in ICNAF division 4W based upon observed data in 1977 and 1978.

	1	2	3	4	5	6
Year	Directed Catch of S.Hake by ICNAF (4W)	Reported Catch of Haddock in Directed Fishery by ICNAF	Reported total Catch of Haddock by ICNAF	Estimated Haddock Catch in Directed S.Hake Fishery	Difference Between Reported and Estimated	Adjusted Haddock Catch for ICNAF
					(4-2)	(3+5)
1971	122415	279	475	918	639	1114
1972	107969	102	106	810	708	814
1973	263511	76	76	2014	1938	2014
1974	81131	91	132	609	518	650
1975	95298	52	52	715	663	715
1976	78954	10	24	525	507	531
1977	20155	10	14	121	111	125
1978	41925	-	131	377	-	377
1979	44411.5 ³	-	148	400	-	400
1979 ⁴	44940	-	72 ⁵	405	-	405

¹ Adjusted Haddock Catch = [Total Reported Haddock - Haddock Catch in S.Hake] + Estimated Haddock Catch.

² Report of directed fisheries not available from ICNAF to date. Estimated from Observer Programme.

³ Reported to Canada and entered into the FLASH system.

⁴ Reported in NAFO Circular Letter 80/9 - February 12, 1980

⁵ Excludes 4W + 4X.

Table 3. Removals ('000) at age for USSR commercial catches of 40W Haddock.

AGE	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0	6.7	11.5	14.6	19.7	45.110	106.9	12.5	4.7	4.7	2.31	1.79	45.5	290	26	318	348	36	105	1
2	0	1.6	2.1	3.0	4.3	40.510	200.9	10	41	6.5	0.4	40.2	95	101.6	21.6	36	230	60	170	15.6
3	0	1.9	3.3	4.1	5.2	510.75	97.15	1.2	2.2	9.5	1.5	1.3	2.1	2.2	29.3	132	40	51	150	168
4	0	1.5	2.1	2.9	3.9	10.27	410.2	2.34	6.9	6.1	1.19	1.27	1.69	2.2	5.1	110	90	24	69	176
5	0	3.4	5.0	7.4	9.2	20.76	15.97	2.27	5.5	15	5.4	3.0	1.30	105	54	29	103	27	21	50
6	0	10	17.5	23.5	39.9	35.62	5.40	60	35	5.4	3.9	3.6	0.6	209	27	52	22	11	34	6
7	0	3	4.9	6.3	10.3	10.4	1.20	20	10	3.4	5.1	1.6	4.6	35	19	14	25	2	6	5
8	0	5	10	13	13.7	10.5	0	45	11	7	1.4	2.6	2.6	5.3	6	6	5	1	2	2
9	0	1	1.2	1.5	20	210	0	12	6	10	7	3	1.5	17	5	3	2	1	3	10
10	0	1	10	1.5	1.7	39	0	15	4	2	0	0	7	19	2	3	2	0	0	0
11	0	5	6.5	11.9	15.9	5.5	0	10	2	1	2	0	0	0	3	0	2	1	3	0

Table 4. Haddock numbers-at-age ('000) from research vessel surveys in 4W.

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
0	273	161	40	0	594	192	780	645	0	3874
1	7100	4489	3435	1508	944	12025	8547	15666	25779	229
2	2640	9451	2321	4978	5587	1700	9400	29656	28842	23780
3	4788	3117	3378	1490	7556	4991	1322	23396	38613	25874
4	5325	4104	1524	1401	1369	4463	2569	3176	21592	26879
5	2548	1633	1271	514	1409	1170	2465	950	1372	7538
6	1632	925	955	1023	702	2135	542	1879	1234	969
7	1817	426	392	214	523	557	592	531	323	752
8	924	663	186	251	208	226	151	306	39	256
9	388	30	111	81	118	117	41	0	0	0
10	86	0	49	119	86	134	40	179	29	98
11	98	0	0	0	101	0	41	23	36	47

Table 5. Adjusted CPUE index for OTB TC 3-5 for the 4VW haddock stock (CPUE directed)
adjusted to 1966.

YEAR	TC3		TC4		TC5		TOTAL OTB CATCH	WTD CPUE INDEX	GRAND TOTAL CATCH	EFFORT INDEX (HRS)
	CPUE	MT	CPUE	MT	CPUE	MT				
1960	0.6051	767	1.2213	10259			11301	1.1497	27795	24175
1961	2.220	1704	1.4773	14017			16108	1.5204	27196	17887
1962	1.2864	737	0.9398	10003			10792	0.9589	24822	25885
1963	1.4687	598	1.1358	6245			7070	1.1275	25507	22622
1964	0.6300	246	0.9925	5826			6094	0.9743	22778	23378
1965	1.000	299	1.5821	3710		251	4274	1.3733	55070	40100
1966	1.000	357	1.000	7283	1.000	358	8000	0.9997	23421	23428
1967	1.2330	42	1.3174	4649	1.2607	779	5475	1.3075	10747	8219
1968		8	0.8685	4584	0.6365	1666	6261	0.8052	13377	16613
1969			0.7633	3431	0.6289	3367	6798	0.6967	11169	16031
1970	1.2424	120	0.4823	2083	0.4820	1398	3601	0.5075	9820	19350
1971	0.4372	97	0.6541	3592	0.5696	690	4379	0.6360	13672	21497
1972	0.3957	25	0.4688	678	0.3301	978	1681	0.3870	4821	12457
1973			0.4264	1253	0.3502	981	2235	0.3928	6373	16225
1974	1.8456	60	0.1841	153	0.2531	68	281	0.5583	2913	5218
1975	0.3293	19	0.4225	176	0.3987	161	354	0.4091	2583	6314
1976	0.2214	4	0.6135	139	0.1793	92	235	0.4368	2034	4657
1977	0.5202	3	0.4245	166	0.3586	297	438	0.4075	3380	8292
1978	1.9037	28	1.5705	827	0.8090	1343	2198	1.1095	6222	5608

TABLE 5: REPRODUCTION OF A GOOD FUR CARPENTER LARVAE OF THE HATCHLING.

AGE	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	16	343	899	102	0	0	1	21	5	32	331	107	246	67	0	0
3	125	2939	213	30	185	343	899	570	253	289	200	453	176	167	331	107	107	701	415	363
4	2048	2939	977	1403	405	1227	4077	1532	1255	1020	950	1313	336	798	107	454	97	339	1363	1108
5	5106	6309	5004	1327	2094	1100	2342	1943	1965	1525	832	1022	461	533	215	109	150	423	278	590
6	2556	3492	4159	3443	1091	1753	670	853	1730	1434	849	799	343	351	173	80	110	190	465	117
7	1906	1103	1257	1712	1718	539	1160	335	549	699	717	631	179	205	52	35	97	64	137	92
8	1254	868	572	440	939	633	306	463	267	208	224	792	90	74	21	17	22	37	40	5
9	411	701	227	111	237	207	212	162	294	97	46	193	86	31	6	3	4	11	16	3
10	177	179	146	30	50	55	60	131	86	85	27	26	4	53	6	0	6	7	6	1
11	170	57	35	11	61	37	9	42	53	28	0	14	11	1	5	1	5	5	5	1

Table 7. Removals at age ('000) for USSR catches in 1977 estimated by using observed samples and Canadian research.

Age	Canadian Research		USSR Sampled	
	No.	%	No.	%
0	1	0.51	0	-
1	36	18.46	31	19.54
2	60	30.77	68	39.08
3	51	26.15	54	31.03
4	24	12.31	6	3.45
5	7	3.59	8	4.60
6	11	5.64	3	1.72
7	2	1.03	1	0.57
8	1	0.51		
9	1	0.51		
10	0	-		
11	1	0.51		
11+	-	-		
TOTALS	195	100.00	174	100.00

Table 8. Removals-at-age ('000) - 1979 Revised

Age	CANADA OIB		CANADA I. L.		CANADA TOTAL		USSR		Other ² Countries		Total All Countries	
	Jan 80	Apr 80	Jan 80	Apr 80	Jan 80	Apr 80	Jan 80	Apr 80	Apr 80	Jan 80	Apr 80	Apr 80
	Jan 80	Apr 80	Jan 80	Apr 80	Jan 80	Apr 80	Jan 80	Apr 80	Apr 80	Jan 80	Apr 80	Apr 80
0	-	-	-	-	-	-	25	25	6	27	31	
1	-	-	-	-	-	-	1	1	0	1	1	
2	5	7	3	8	11	154	154	156	35	172	202	
3	162	237	105	267	363	167	167	169	38	462	570	
4	446	653	369	815	1108	174	174	176	40	1053	1324	
5	192	281	242	434	590	49	49	50	11	14	651	
6	37	54	49	86	117	6	6	6	1	98	124	
7	24	35	44	68	92	5	5	5	1	78	98	
8	1	1	3	4	5	2	2	2	0	6	7	
9	1	1	1	2	3	1	1	1	0	3	4	
10	1	1	-	1	1	-	-	-	-	1	1	
11	1	1	-	1	1	-	-	-	-	1	1	
11+	1	1	-	1	1	-	-	-	-	1	1	
TOTAL	871	1276	816	1687	2292	584	584	591	132	2418	3015	
Catch (t)	1184	1733 ¹	1152	2336	3176	400	400	405	91	2913	3672	

¹ Includes 91 t from Nfld. & 1642 t from Maritimes.

² Includes countries fishing in 4W. Removals based upon USSR removals.

Table 9. Estimated 4W Haddock catches during the 1979 Scotian Shelf foreign fisheries

Country	Species	1979 RPT ¹ catch (t) in 4W	Estimated catch in 4W from Observer Prog. (t)	Ratio Haddock to directed fishery 4W	Estimated catch (t) of Haddock in 4W
Bulgaria	S. Hake Squid	76.79	99	.006	45.000
Cuba	Argentine S. Hake Squid	566.7 ²	100	.004	22.000
FRG	Squid	1240	100	.000 ³	.002
France	Squid	1926	100	.000 ³	.267
Ireland	Squid	655	100	.000 ³	.002
Italy	Squid	1126	100	.000 ³	.002
Japan	Argentine Squid	6443	99	.004	23.000
Poland	Squid	9827	100	.000 ³	.129
Portugal	Squid	1841	100	.000 ³	.002
Romania	Squid	830	100	.000 ³	.073
Spain	Squid	4436	100	.000 ³	.073
				TOTAL	90.473

¹ Reported to FLASH

² No reported catch for Argentine - observed Argentine was 0.2 t

³ less than .000

TABLE 10. REPRODUCED AND CATCH DATA FOR THE FISH INDUSTRY, 1960-1979.

Year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0	67	1133	1376	1237	45310	10697	123	97	47	251	179	475	270	26	313	318	36	105	1
2	0	16	271	310	379	10750	2297	101	31	63	37	330	100	1030	216	36	303	127	102	202
3	175	233	3412	4101	5707	31410	10634	750	325	381	443	506	447	439	824	312	124	832	565	570
4	2040	3075	3305	4350	4335	5753	8197	1766	1324	1083	1639	1470	505	1060	150	212	172	563	1132	1574
5	5106	6353	5304	7072	3005	3176	5939	2170	2079	1560	306	1090	619	638	269	218	253	430	299	651
6	2256	3502	4314	3668	1590	4415	1226	924	1765	1408	888	835	479	560	200	140	140	201	499	174
7	1906	1106	1306	1775	1001	1393	1200	375	567	735	760	647	275	240	71	49	122	66	143	90
8	1754	873	652	551	1076	730	306	500	270	215	230	810	124	127	27	23	27	30	42	7
9	311	702	239	175	252	497	212	174	300	107	53	174	101	40	7	6	6	12	19	4
10	172	100	156	43	67	94	60	146	90	183	22	26	11	75	0	3	0	7	6	1
11	170	62	120	130	190	90	9	52	55	29	10	14	11	1	0	1	2	6	5	1

Table 11a. Adjustment of survey estimates numbers at age ('000) at $M = 0.2$ for ages 1 to 3 to compensate for partial recruitment relative to age 4.

Survey Year	Y E A R C L A S S			
	1978	1977	1976	1975
1979	407	33364	23912	26879
1978		45834	40466	
1977			27854	
Average	407	39599	30744	26879
Ratio to Age 4	0.015	1.473	1.144	1.000

Table 11b. 1979 research survey numbers at age ('000) prior and after adjustment to compensate for partial recruitment at age 4.

AGE	1	2	3	4
Original #'s	229	23780	25874	26879
Adjusted #'s	407	39599	30744	26879

Table 12. Initial and Final Partial recruitments and mean weights at age.

Age	1	2	3	4	5	6	7	8	9	10	11
Initial Par. Rec.	.010	.060	.178	.386	.673	1	1	1	1	1	1
Final Par. Rec.	.010	.050	.178	.550	.673	1	1	1	1	1	1
Mean wt. at age (kg)	.105	.500	.820	1.220	1.690	2.150	2.600	3.020	3.630	3.900	3.61

Table 13. Population numbers ('000) and fishing mortalities at $M = 0.2$
1950-1977

	1950	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	465.02	31190	46904	86108	97065	66007	11305	10103	7702	4017	3561	2991	3175	7054	5650	29900	51101	52063
2	203.59	30155	25176	37375	59102	76000	13692	2530	0151	6170	3097	4344	2707	4846	6160	4602	24192	41509
3	292.01	16644	31774	20612	30706	56708	25590	9167	6015	6545	4993	3114	3160	1702	2056	4054	5735	19369
4	2313	20040	18416	27430	13093	19632	17591	11336	5057	4531	3693	3600	2019	2109	1062	1773	3606	2946
5	14615	19705	18900	4012	14554	6709	7240	6903	7683	4591	2011	3502	1671	1196	042	726	934	2041
6	6265	7346	10377	0704	4684	0737	2619	1035	1107	1477	2307	905	473	008	402	446	397	546
7	4076	2017	2045	4656	4073	2570	2039	1035	526	395	546	1194	221	103	155	140	239	199
8	3733	2195	1306	1148	2506	1341	050	1159	106	127	231	13	23	60	35	38	31	39
9	1151	1469	1007	479	441	033	594	419	106	129	50	56	14	103	13	22	26	20
10	350	570	568	600	270	129	232	294	106	129	26	21	23	1	17	3	16	14
11	410	130	304	325	459	167	20	120	109	71	26	21	23	1	17	3	16	14
12	155161	144340	150426	190557	233922	230921	02568	50545	42440	33350	27597	21327	1200	19190	17274	42576	84513	120499

FISHING MORTALITY

	1950	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.000	0.002	0.027	0.019	0.023	1.305	0.702	0.014	0.006	0.011	0.047	0.030	0.005	0.042	0.005	0.012	0.008	0.001	0.002
2	0.000	0.000	0.012	0.010	0.000	0.009	0.701	0.027	0.006	0.011	0.024	0.116	0.070	0.207	0.039	0.009	0.022	0.003	0.005
3	0.005	0.016	0.130	0.254	0.734	0.962	0.615	0.095	0.062	0.066	0.103	0.233	0.170	0.310	0.276	0.075	0.037	0.049	0.019
4	0.122	0.152	0.316	0.247	0.459	0.796	0.754	0.109	0.241	0.299	0.764	0.591	0.324	0.755	0.100	0.441	0.060	0.146	0.111
5	0.400	0.435	0.453	0.357	0.355	0.741	0.910	0.421	0.343	0.499	0.420	1.058	0.526	0.090	0.435	0.403	0.356	0.103	0.173
6	0.599	0.740	0.511	0.619	0.397	0.065	0.720	0.551	0.733	0.460	0.597	0.955	0.734	1.451	0.790	0.426	0.493	0.535	0.335
7	0.590	0.569	0.700	0.547	0.771	0.909	0.696	0.476	0.035	0.795	0.879	1.296	0.747	1.340	0.705	0.435	0.033	0.457	0.954
8	0.733	0.579	0.003	0.756	0.774	0.753	0.507	0.665	0.076	0.927	0.630	1.415	0.920	1.451	0.497	0.519	0.490	0.682	0.599
9	0.502	0.751	0.304	0.543	1.032	1.070	0.502	0.614	1.132	1.076	0.615	2.611	0.635	1.492	0.349	0.192	0.245	0.421	0.910
10	0.756	0.479	0.567	0.001	0.310	1.645	0.591	0.794	0.760	1.399	0.665	0.712	2.070	1.630	1.200	0.160	0.423	0.502	0.385
11	0.625	0.675	0.516	0.730	0.601	0.002	0.659	0.504	0.797	0.597	0.243	1.766	0.754	1.300	0.749	0.439	0.669	0.647	0.823
12	0.136	0.156	0.104	0.130	0.120	1.033	0.583	0.107	0.220	0.244	0.757	0.366	0.241	0.372	0.123	0.050	0.025	0.021	0.026

1978

1	0.003
2	0.005
3	0.010
4	0.055
5	0.067
6	0.100
7	0.100
8	0.100
9	0.100
10	0.100
11	0.100
12	0.070

Table 14. Yield per recruit for the 4W Haddock ($M = 0.20$, partial recruitment and wt. at age as in Table 10).

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (G)	AVG. WEIGHT (NO)	YIELD PER UNIT EFFORT
	0.050	0.08534	0.198	2.246	1.000
	0.100	0.15351	0.337	2.153	0.849
	0.150	0.20972	0.434	2.065	0.728
	0.200	0.25244	0.501	1.983	0.631
	0.250	0.28684	0.547	1.908	0.551
	0.300	0.31513	0.578	1.835	0.486
F0.1---	0.313	0.32175	0.588	1.817	0.471
	0.350	0.33877	0.599	1.769	0.432
	0.400	0.35883	0.613	1.709	0.386
	0.450	0.37611	0.622	1.653	0.348
	0.500	0.39119	0.627	1.602	0.316
	0.550	0.40451	0.629	1.552	0.288
FMAX---	0.590	0.41531	0.630	1.516	0.267
	0.600	0.41640	0.630	1.512	0.264
	0.650	0.42713	0.628	1.472	0.244
	0.700	0.43388	0.627	1.435	0.226
	0.750	0.44082	0.625	1.402	0.210
	0.800	0.45406	0.622	1.370	0.196
	0.850	0.46171	0.619	1.341	0.184
	0.900	0.46884	0.616	1.314	0.172
	0.950	0.47552	0.613	1.288	0.163
	1.000	0.48180	0.609	1.265	0.154

Table 15. 4W Haddock population numbers ('000) using terminal $F = 0.4$ and $M = 0.3$. Option 2.

POPULATION NUMBERS

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	46602	31190	46904	86108	95065	68807	11285	10104	7582	4788	5581	3003	6129	6792	5663	31195	62335	73512	73745	474
2	20359	38155	25476	37376	69182	76080	13692	7548	8161	6170	3877	4361	2297	4608	5298	4613	25253	50737	60346	59873
3	29501	16644	31224	20612	30286	56208	25598	9167	6015	6645	4994	3098	3101	1790	2824	4142	3744	20237	41475	49152
4	27313	24040	13416	22450	13093	19632	17591	11336	6827	4631	5093	3688	2006	2200	1068	1748	3103	2954	150161	33405
5	14615	19785	16900	8012	14354	6709	7248	6983	7683	4391	2811	3202	1671	1185	851	732	913	2364	2090	11653
6	6265	7346	10477	8784	4684	8237	2619	2370	3754	4463	2184	1500	912	808	393	453	402	519	1546	1440
7	4876	2817	2845	4656	3073	2578	2839	1035	1107	1477	2307	985	473	358	155	141	245	202	248	815
8	3733	2195	1306	1148	2206	1541	850	1159	526	393	546	1194	221	183	76	63	71	90	106	70
9	1151	1469	1007	479	441	833	594	419	489	179	127	231	230	68	35	38	31	34	39	49
10	358	570	568	608	278	129	232	294	186	129	50	56	14	103	13	22	26	20	17	15
11	418	138	304	323	459	167	20	128	109	71	26	21	21	1	17	3	16	14	10	10
1	15161	144348	150426	190557	233922	230921	82568	50545	42440	33336	27598	21340	17163	18098	16394	43151	96158	150782	194773	156953

Table 16. 4W Haddock fishing mortalities at terminal $F = 0.4$ and $M = 0.2$. Option 2.

FISHING MORTALITY

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1	0.000	0.002	0.027	0.019	0.023	1.385	0.202	0.014	0.006	0.011	0.047	0.068	0.085	0.048	0.005	0.011	0.006	0.001	0.002	0.003
2	0.000	0.000	0.012	0.010	0.008	0.889	0.201	0.027	0.006	0.011	0.075	0.115	0.049	0.289	0.046	0.009	0.021	0.003	0.003	0.004
3	0.005	0.016	0.130	0.254	0.234	0.962	0.615	0.095	0.062	0.066	0.103	0.235	0.169	0.316	0.240	0.089	0.037	0.047	0.015	0.012
4	0.122	0.152	0.316	0.247	0.469	0.786	0.724	0.189	0.241	0.299	0.264	0.591	0.326	0.750	0.178	0.449	0.072	0.146	0.105	0.116
5	0.480	0.436	0.454	0.337	0.355	0.741	0.918	0.421	0.343	0.499	0.428	1.056	0.526	0.903	0.430	0.399	0.365	0.274	0.172	0.167
6	0.598	0.748	0.611	0.619	0.397	0.865	0.728	0.561	0.733	0.460	0.597	0.955	0.734	1.451	0.826	0.417	0.486	0.559	0.441	0.770
7	0.598	0.569	0.708	0.547	0.721	0.909	0.896	0.476	0.835	0.795	0.459	1.296	0.747	1.348	0.705	0.485	0.801	0.447	1.051	0.400
8	0.733	0.579	0.803	0.756	0.774	0.753	0.507	0.662	0.676	0.927	0.658	1.415	0.970	1.451	0.497	0.519	0.544	0.630	0.577	0.323
9	0.592	0.751	0.304	0.344	1.032	1.078	0.502	0.614	1.132	1.076	0.615	2.611	0.635	1.492	0.249	0.192	0.245	0.499	0.767	0.356
10	0.756	0.429	0.362	0.081	0.310	1.645	0.391	0.794	0.768	1.399	0.665	0.712	2.070	1.630	1.208	0.160	0.423	0.502	0.503	0.704
11	0.626	0.675	0.616	0.578	0.601	0.882	0.659	0.584	0.797	0.597	0.543	1.266	0.754	1.388	0.749	0.439	0.669	0.647	0.823	0.400
1	0.136	0.156	0.164	0.130	0.120	1.033	0.543	0.187	0.228	0.244	0.227	0.565	0.241	0.395	0.130	0.050	0.022	0.017	0.021	0.053

Table 17. Comparison of age 3 F numbers from cohort analyses using various terminal F's compared to age 3+ research vessel survey numbers of the 4W Haddock stock (nos. $\times 10^{-3}$).

1979 3+ numbers	0.1	0.2	0.4	0.6	0.8	1.0
Research	62413	62413	62413	62413	62413	62413
Cohort	375032	189396	96607	65701	50267	41020
Predicted from Regression	284233	145179	84704	52541	40991	34076
Cohort - Reg.	90799	44218	11903	13160	9276	6944
r =	0.941	0.943	0.945	0.942	0.934	0.920

